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BLOOD CONCENTRATIONS DURING PNEUMONIA

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Ever since the investigations of Leyden[1], it has generally been assumed that water retention occurs during fever. This assumption has never been exactly proven. More recently, it has been directly disputed by Schwenkenbecher and Inagaki[2]. These authors have examined muscle and liver portions of their water content from individuals who had died from feverish affections. They found that it was indeed elevated, but not as a result of an absolute increase of water but as a result of an absolute decrease of solid substances. They concluded from this that the cause was not water retention but loss of solids (consumption). It is questionable whether this conclusion permits a generalization. For it can no doubt be assumed that an especially severe consumption was exhibited in the cases investigated which were all fatal. It is possible that a probable absolute increase of the water content was thereby masked. However, the conclusion that the consumption is the cause of the dilution in all cases of infectious disease, especially in those which recover, is not directly justified. The numerous observations made that the body weight often increases during fever and again decreases after the abatement of the fever especially argues against this assumption. The opposite conditions would be expected during simple consumption.

On these grounds, investigations on the water content in the living during feverish diseases would be desirable. Simultaneously, continuous body weight measurements must be of special interest. The investigations of the water content of living people must naturally be limited to blood investigations. Even if the exchange of fluids inside the body does not always proceed so quickly and so completely throughout that a homogeneous distribution of the water in the various tissues can be assumed, there is ~~still~~ doubtless a relation existing between the water content of the blood and the tissues, which more or less occasions a strong parallel[3]. Therefore, certain inferences can be drawn on the water content of the entire organism from the water content of the blood. Continuous investigations of blood concentration and body weight have been made in this clinic during various infectious diseases. In particular, I have investigated a number of cases of croupous pneumon[illegible].

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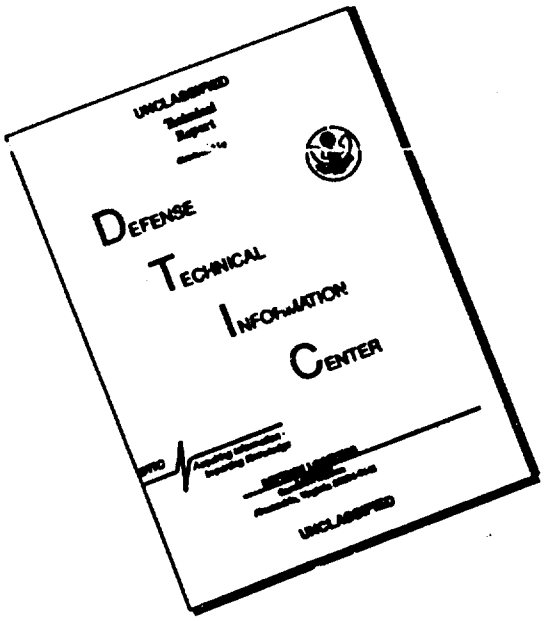

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In this disease, there occurs still another question, frequently aired, to be answered. The deficiency of salt in the urine during pneumonic fever is a known fact. To explain this, Traube[4] has assumed that the salt did not resorb in the alimentary canal during pneumonia, but was eliminated in the feces. This assumption is refuted by the investigations of Schwenkenbecher and his coworkers who demonstrated that normally, as well as during acute infectious disease, only very small amounts of chlorides are eliminated with the stool. Even in diarrhetic typhus stools, the quantity of salt eliminated does not amount to more than 0.1-0.2 g daily. According to the investigations of Reiss, the value does not exceed 0.5 g daily in nephritis. Likewise, according to Schwenkenbecher and Spiro[5], 1.0 g salt at the most was eliminated through perspiration. Also, no more than 0.3-0.5 g of salt per day was removed from the sputum of pneumonia victims. However, the salt retention during pneumonia often amounts to 5.0 g and more per day. Therefore, it is a case of actual salt retention in the body, not a matter of a deficiency of salt in the urine as a result of decreased resorption. Radtenbacher and Beele[6] see the cause of this salt retention as lying in the salt content of the pneumonic exudate. They made comparative determinations of the percent salt content of healthy and hepatic lungs and found an increase in the latter. From a series of further determinations by Verray, Hutchinson, Jarist, Meillere[7], it follows meanwhile that there is only a very slight increase over the normal: From 0.3-0.5% NaCl to 0.33-0.5% NaCl. This shows an increase of around 0.1 g NaCl calculated on the absolute weight of the hepatic lung. Therefore, there must be still other sources for the significant salt retention of the pneumonia victim. Often, for this reason, the assumption was made that the salt retention was an effect of the asserted water retention. To my knowledge, an exact proof for this supposition has not hitherto been produced. On the instigation of Herr Dr. Ludwig and with the assistance of Herr Dr. Reiss, I have now made simultaneous determinations of salt balance and blood concentration in my cases.

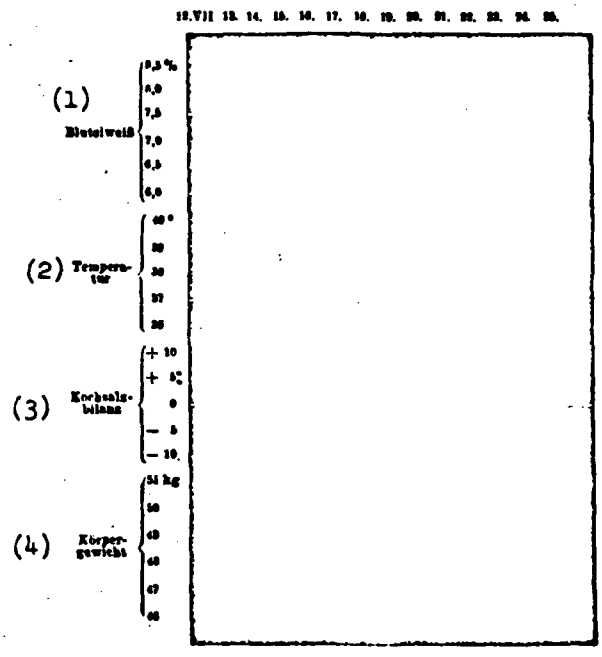
The refractometer[8] was used for the determination of the blood concentration. The blood was taken each morning before eating; the body weight was simultaneously taken. The determination of the salt balance took place according to the principles given in the preceding work by Reiss.

I begin with the typical curves.

Case 1

Anna M., 22 years. Admitted to the hospital 11 August 1903. Five days before, stinging in the right side. Now, coughing and bloody sputum, shortness of breath, exhaustion. Status: Medium-sized patient in moderately nourished condition. High fever; dyspnoea. Cyanosis. Congestion at the lower right back. Bronchial respiration. Urine: Albumen + Diazo-R.-. Diagnosis: Croupous pneumonia of the right lower lobe. Progress: After hospitalization for five days, fall of temperature, improvement, recovery (see curve 1).

Curve 1. Marz, Anna, Pneumonia



Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

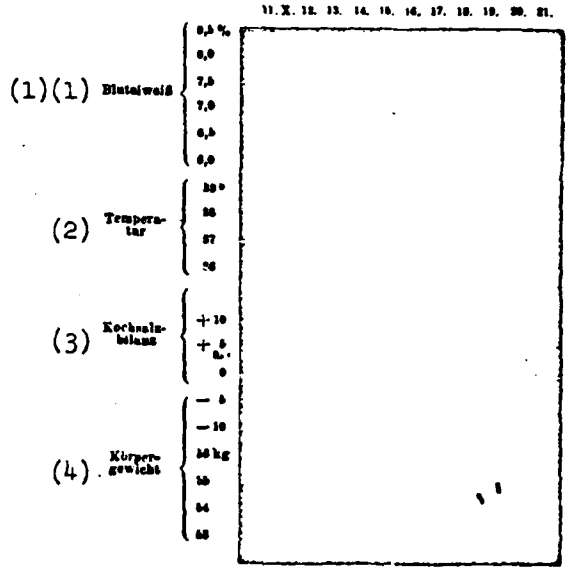
It is evident from the curve that in the first days of hospitalization, as a high fever was still present at the time, an increase of the body weight and a further decrease of the blood concentration, already previously under the norm, occurred. Simultaneously, a significant salt retention was present. With a critical temperature fall, a prompt rise of the blood concentration to normal values occurred--the difference amounted to over 1.5% albumen in five days-- and a weight loss of 4.6 kg in four days resulted. Simultaneously, the positive salt balance changed into a negative one. This curve is absolutely clear. Salt was retained during a feverish period. It follows from the body weight increase that water was retained at the same time -- whether primarily or secondarily should not be debated here. It should be noted here that we did not know the body weight of the patient before the illness. In any case, after the course of the illness, during the convalescence period (19-25 Ausust), it moved constantly to a much lower level. It follows from the converse behavior of the body weight and the blood concentration that the blood dilution essentially depended on water retention. If consumption had been the cause, it would have to be

assumed that the body weight would also rise along with further increase in blood concentration.

Case 2.

Heinrich Sch., 53 years. Admitted on 9 October 1908. Three days before suddenly taken sick with chills, stinging in the left side, coughing and headaches. Status: Strong man. Temperature 38°. Mild dyspnoea. Tight congestion over the lower left lobe with bronchial respiration. Urine: Albumen+ Diazo-R.-. Diagnosis: Croupous pneumonia of the lower left lobe. Progress: After three days of hospitalization, lytic temperature fall. Progressive improvement, recovery.

Curve 2. Schwab, Heinrich, Pneumonia



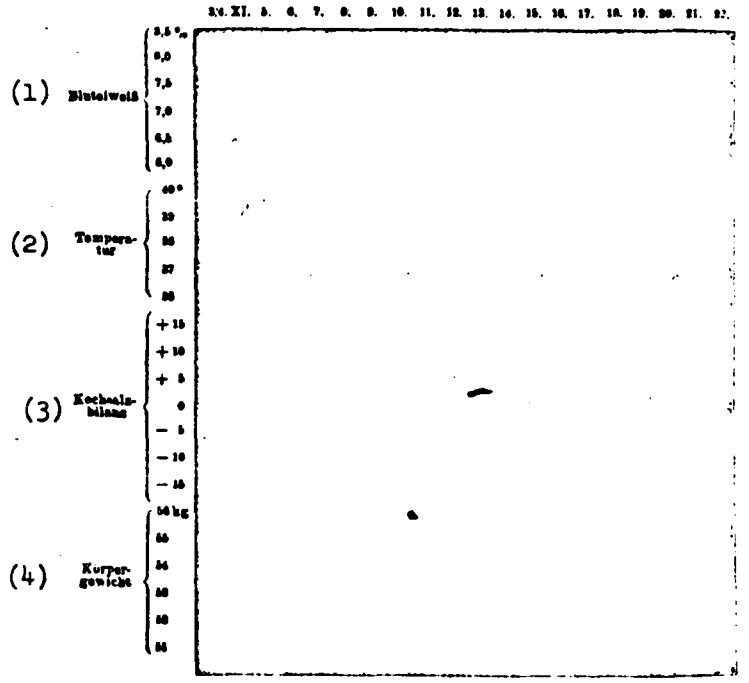
Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

It can be discerned from the curve of the patient that his weight remained constant during the period of fever. A decrease in weight took place with the fall of temperature -- around 1.0 kg in two days -- and simultaneously, the positive salt balance changed into a negative one. Parallel to the salt secretion setting in at this time was the reduction of aqueous constituents in the blood. The blood assumed a normal concentration during further fever-free progress. Towards the end of the hospitalization, the weight of the patient increased which was attributable to increased food intake and substantial anabolism in the convalescence period.

Case 3.

Karl B., 27 years. Admitted 2 November 1908. Three days before taken ill with chills, stinging in the right side, coughing and brownish sputum. Status: Scarcely medium-sized man in moderately nourished condition. High fever. Congestion at the lower right back. Bronchial respiration. Urine: Albumen+ Diazo-R.-. Diagnosis: Croupous pneumonia of the lower left lobe. Progress: Critical fall of temperature on the third day of hospitalization. Progressive improvement, recovery (see curve 3).

Curve 3. Busch, Karl, Pneumonia



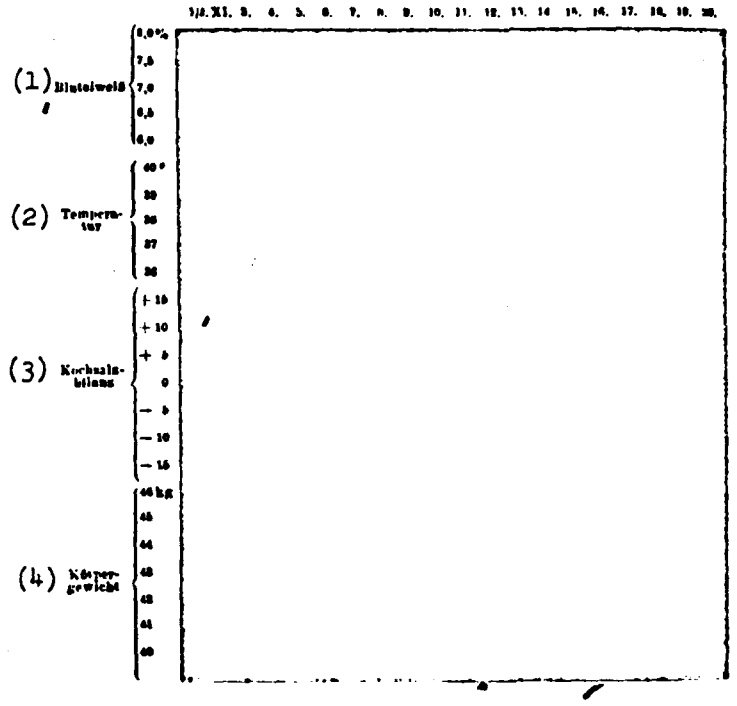
Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

His curve shows: significant weight decrease with the critical temperature fall -- two kg in two days -- and change of the positive salt balance into a negative one. With increased salt elimination, gradual rise of the blood concentration which of course did not entirely reach normal levels during the period of observation. The critical perspiration is considered as an external sign of the incipient concentration of the blood. When the patient was in the reverse salt equilibrium the weight curve further increased with increasing appetite.

Case 4.

Karl R., 15 years. Admitted 31 October 1903. Six days before, sudden chills, headache. He still worked on the following day. The stinging in the right side of the breast increased. Coughing, reddish sputum, shortness of breath, exhaustion. On the sixth day of illness, entry into the hospital. Status: 15 year old youth. Strongly built, ordinary condition of nourishment. High fever. Congestion at the lower right back. Bronchial respiration. Urine: Albumen+ Diazo-R.+. Pneumocci+ in the sputum. Diagnosis: Croupous pneumonia of the lower right lobe. Progress: Critical fever decrease on first to second day of hospitalization. Recovery.

Curve 4. Rumbler, Karl, Pneumonia



Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

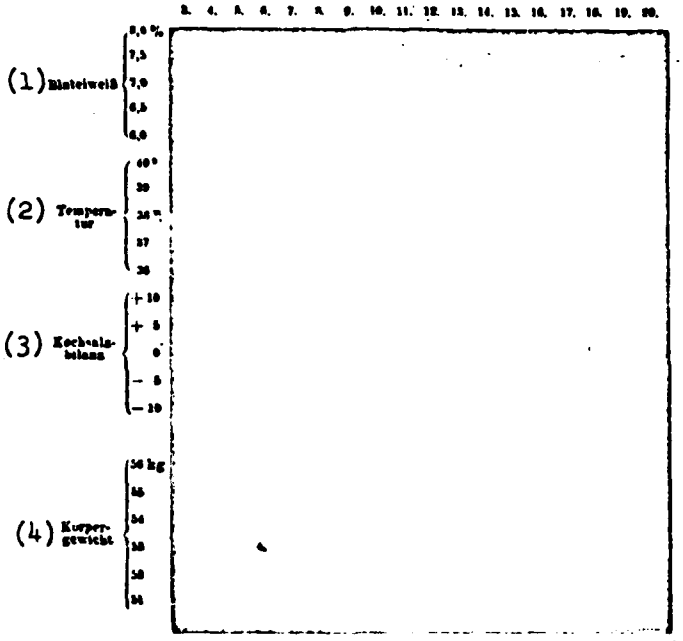
His curve further shows the same result: weight loss accompanying the fever decrease (see curve 4).

The actual period of fever took place before entrance into the hospital. Change of the positive salt balance into a negative one and decrease of water in the blood occurred. Normal blood concentrations occurred towards the end, with fever-free progress, and increase of weight with heightened appetite with well-being.

Case 5.

Carl R., 31 years old. Suddenly taken ill four days before with chills, coughing, sputum which appeared reddish, and stinging in the right side of the breast. Status: Medium-sized man in a well nourished condition. Pulse without result. Congestion over the right lung at the lower back with bronchial respiration and resounding rattling. Urine: Albumen+ Diazo-R.-. Diagnosis: Croupous pneumonia of the lower right lobe. Progress: Critical temperature decrease on the third day of hospitalization. Progressive improvement. Recovery. (See curve 5.)

Curve 5. Raible, Pneumonia



Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

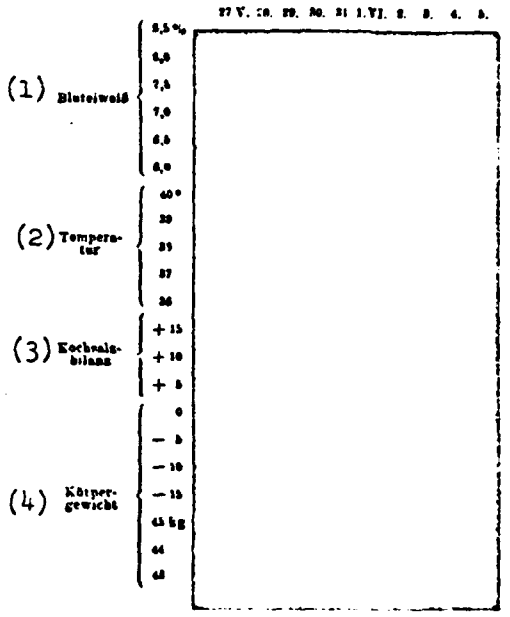
We see from his curve that the salt retention as well as the hydremia outlasted the fever period by about three days. Concentration of the blood and a weight loss of 1.5 kg took place with the onset of salt secretion. Furthermore, the salt balance was influenced by salt additions which were given twice for three days. I will return to this below. Towards the end of the hospitalization, there was increase of body weight and concentration of the blood to normal levels with increasing improvement and food intake.

Case 6.

Marie St., 28 years. Admitted 26 May 1908. Three to four days before, pains in the left side while breathing. No chills. Sensation of heat. No sputum. Status: Medium-sized patient in sufficiently nourished

condition. Mild cyanosis. No dyspnoea. Temperature 37.9°. Congestion under the left lower lobe with severe bronchial respiration. No sputum. Urine: Albumen-, Diazo-R.-. Progress: Fever reduction on the second day of hospitalization. Growing improvement. Recovery. The patient entered the hospital only towards the end of the feverish period of her illness (see curve 6).

Curve 6. Stahl, Pneumonia



The urine was regularly free of albumen.

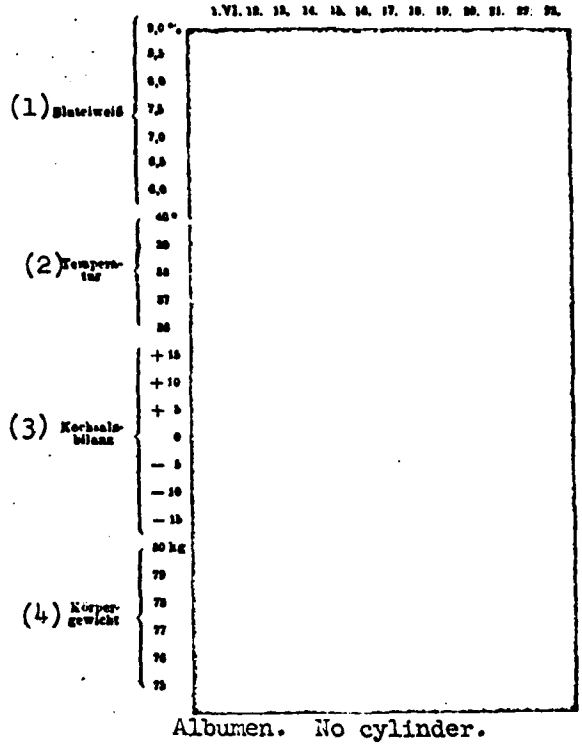
Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

In spite of the positive salt balance during the feverish period and in spite of a reduction of the blood concentration, the body weight showed a slight tendency to fall during the feverish period. Nevertheless, the weight loss became more severe at the time of the negative salt balance and blood concentration.

Case 7.

Elise K., 41 years. Admitted 10 June 1908. Four days before, sudden chills, stinging in the left side. On the day afterward, coughing and brown sputum, high fever. Status: Strongly built, well-nourished patient. Mild cyanosis. Temperature 39.5°. Congestion above the lower left lobe with bronchial respiration and resounding rattling. Urine: Albumen+, Diazo-R.-. Progress: On the sixth day after hospitalization, temperature decline. Progressive improvement. Recovery. (See curve 7.)

Curve 7. Konig, Elise, Pneumonia



Albumen. No cylinder.

Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

Curve: the temperature shows strong remission. The body weight fell only slightly -- several hundred grams -- during fever remission. However, with complete fever remission, there was a considerable weight loss -- 2.2 kg in three days. The hitherto positive salt balance changed into a negative one and the blood water decreased.

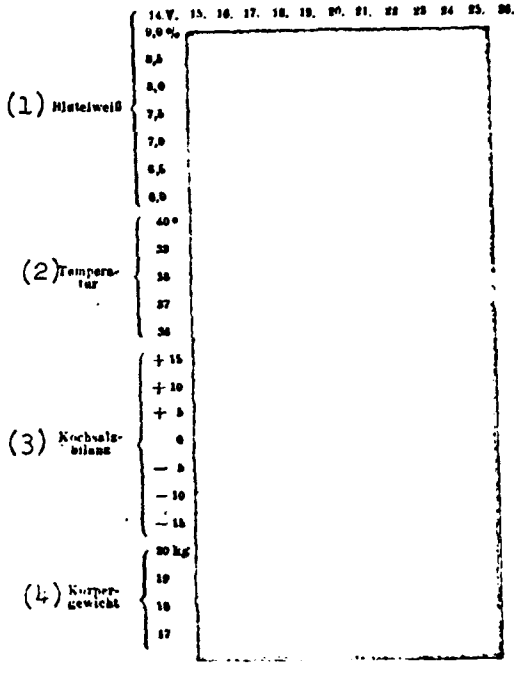
Case 8.

Karl E., 7 years. Admitted on 13 May 1908. Anemic. The only thing that could be learned from the small patient was that he had had abdominal pains for three days. Status: Insufficiently nourished youth. Temperature 39°. Mild cyanosis. Shallow accelerated breathing. Upper right half of the thorax lagged during respiration. Congestion at the upper right back. Bronchial respiration, resounding rattling. Urine: Albumen-, Diazo-R.-. Progress: Critical temperature decline after two days of hospitalization, increasing improvement. Recovery.

This patient also came to the hospital only shortly before the decline of the fever, so that we were not informed about his previous body weight.

From the curve, we see a slight increase of body weight during the fever which outlasted the critical temperature decline by a day and then remained almost constant during the fever-free period. Instead of salt retention, slight salt secretion occurred which, however, extended over a long period. The blood concentration only assumed higher values slowly.

Curve 8. Ehemann, Karl, Pneumonia



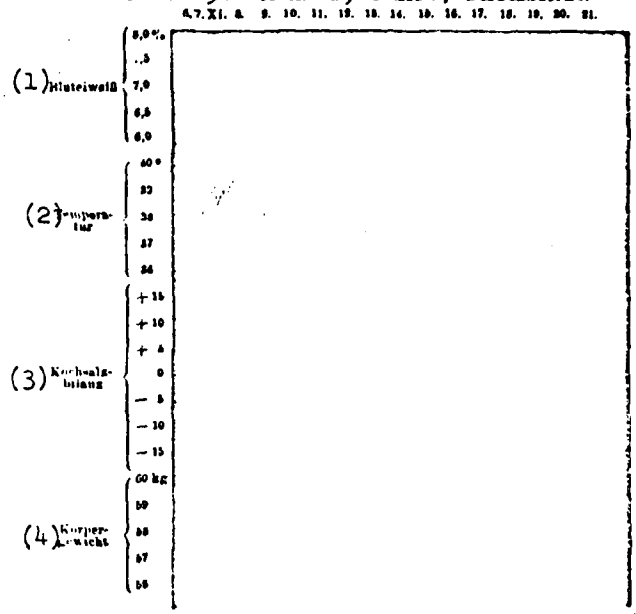
Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

Case 9.

Jakob K., 23 years. Admitted 5 November 1903. One day before admission sudden chills, stinging in the left side of the breast, shortness of breath. No cough. No sputum. Status: Medium-sized strong man in well-nourished condition. Tight congestion at the lower left back. Bronchial respiration. Temperature 39°. No sputum. Urine: Albumen-, Diazo-R.-. Diagnosis: Croupous pneumonia. Progress: Delayed discharge, lengthy gradually diminishing fever. Congestion still present. Patient is still in treatment at this time. The investigations were interrupted by the onset of salt equilibrium.

During the slowly declining fever, there was a constant weight loss which, however, became rapid at the time the positive salt balance changed to a negative one. Towards the end, the coincidence with slight temperature rises, there was an increase of weight. During the salt secretion period, there was a slowly increasing concentration of the blood.

Curve 9. Keller, Jakob, Pneumonia



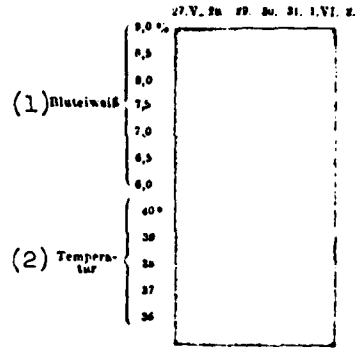
Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

Case 10.

Katherine E., 55 years. Admitted 24 May 1908. Two days before being directed into the hospital, chills, stinging in the right side, difficulty in breathing. No sputum. Status: Medium-sized strongly built woman in well-nourished condition. Moderate adiposity. Mild cyanosis. No herpes. Congestion at the lower right back, bronchial respiration, resounding rattling. Urine: Albumen+, Diazo-. Diagnosis: Croupous pneumonia of the lower right lobe. Progress: The pneumonic infiltration spread gradually, accompanied by increasing dyspnoea and cyanosis over the entire lung. It caused heart weakness and proved fatal on the seventh day of hospitalization.

Because of the miserable condition of this patient, neither daily weight measurements nor a salt exchange could be undertaken. However, the curve does go so far as to indicate that the blood became richer in water with the rise in temperature, and became deficient in water with the decline in temperature.

Curve 10. Eberts, Pneumonia



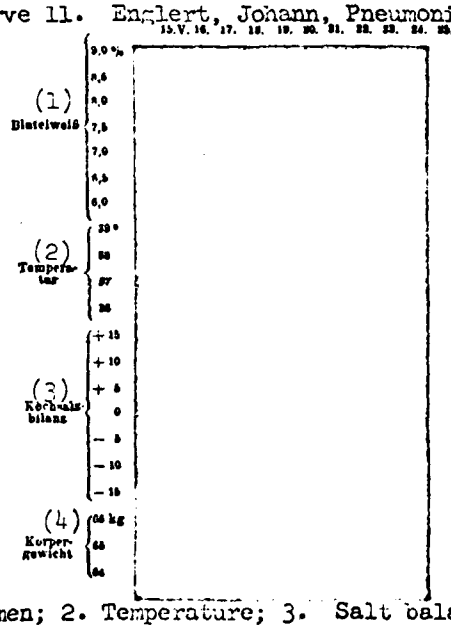
The urine constantly contained traces of albumen.

Key: 1. Blood albumen; 2. Temperature

Case 11

Johann E., 25 years. Admitted 11 May 1908. One day before admittance to the hospital, sudden chills, stinging in the left side of the breast, coughing, yellowish sputum. Status: Strongly built man, ordinary condition of nourishment. Temperature 38.3°, mild cyanosis. Shallow breathing. Congestion at the lower left back with bronchial respiration and resounding rattling. Urine: Albumen+, Diazo-R.-. Diagnosis: Croupous pneumonia of the left lobe. Progress: Critical decrease of temperature on the fifth day of hospitalization. Progressive improvement. Recovery (see curve 11).

Curve 11. Englert, Johann, Pneumonia



Key: 1. Blood albumen; 2. Temperature; 3. Salt balance; 4. Body weight

The weight remained nearly constant during the feverish period. The weight did not decrease with the critical temperature decline, but remained at the same level for about three days. Thereafter, the weight increased about 0.5 kg. It should be noted that this patient had an extraordinarily strong appetite throughout the entire duration of this illness. It is therefore likely that the absence of a weight decrease in spite of the great water deficiency in his blood occurring with the decline of temperature is connected with the assimilation of large quantities of nourishment. The negative salt balance occurring after the fever reduction coincided with increasing blood concentration.

If we survey all our curve material, we can distinguish between two large groups, curves 1-7 comprising Group 1, curves 8-11 Group 2. Group 1 is characterized by increasing or at least constant body weight during the fever, more or less rapidly decreasing weight with the decline of fever, weight increasing again during subsequent convalescence. We must assume, from all that is known about this, that the breakdown of solids exhibits its greatest intensity during the period of high fever. If the breakdown of solids is the cause of dilution of the body liquids, this must lead to a decrease of body weight. But in the seven cases mentioned, the opposite was observed. The body weight increased or remained constant with the decrease of blood concentration in the period of fever. Conversely we must assume that an increase of blood concentration, when it depends on the replacement of lost albumen by an external supply, is accompanied by a weight increase. We see the opposite of this also in our curves. The blood becomes more concentrated with a decline of fever, but the body weight falls. The further concentration increase of the blood serum accompanied by a weight increase can only be replacement of lost albumen during the subsequent reconvalescence period. In these first seven cases, therefore, consumption cannot be the only cause of the blood dilution. Rather, consumption plays only a subordinate role here. The chief cause of the blood dilution can be none other than an actual water (or salt solution) retention, an increase of the absolute water content of the organism. This explanation is supported by the rate of NaCl secretion. We consistently observed a retention of NaCl during the periods in which we have supposed a retention of water. Therefore, NaCl and water are retained simultaneously, corresponding to the ideas on the tendency of the organism to preserve its osmotic pressure. We know that the osmotic pressure of the blood supports only relatively slight fluctuations. We must therefore conclude that the severe dilutions of albumen concentrations which we have found in pneumonia do not also signify dilutions of its salt concentration. Therefore, more absolute NaCl must be contained in the increased absolute liquid quantity of the total body. Herein lies the simple answer to the question of where the salt retained in pneumonia comes from. In our opinion, the hypothesis that the NaCl retention in pneumonia is centered in the lung exudate, fails. Rather, in our opinion, the NaCl during pneumonia (and other illnesses) is secreted in small concentrations because it is necessary for the maintenance of the isotonicity of the increased amount of body liquids. The relations in Group 2 (cases 8 - 11) are less simple. Here we see a decrease of the body weight during the fever and an increase after the

decline of the fever. The blood is also diluted during the fever in these cases and its concentration rises after the fever reduction. We need to realize that this is the relation if we assume consumption as the cause of the body fluid dilution.

However, from the continually positive salt balance during the fever as well as its change into a negative balance after fever reduction, it proceeds that consumption is not the only cause.

Therefore, in our second group of cases, the breakdown of body materials has an essential role in the fluid dilution without entirely suppressing the water retention. Therefore, it is only partly a matter of different qualitative behavior, but rather, essentially a matter of a quantitative fluctuation. Water retention appears to be present almost continually during fever, but its action on the body weight is often compensated or overcompensated for by the simultaneous loss of other tissue materials. The quantitative changes in the composition of the tissue during fever are therefore mostly limited by both causes. First one predominates, then the other. If water retention is the main cause for the symptoms described in mild lung afflictions which attack strong individuals, it is easily understandable that consumption appears foremost in cases of weak individuals in severe and especially in fatal cases (as those investigated by Schwenkenbecher and Inagaki).

The question is now raised: Why is the water retained during fever? In close connection to this, the question to be discussed is: why is the salt retained? To take the latter first, the view that the salt is bound to a certain extent by the pneumonic exudate is not tenable according to the statement made above. It is certain that by and large salt and water are retained simultaneously. Both are essentially secreted through the kidneys, the salt more exclusively than the water. The skin, lungs and intestine play a greater role in the secretion of water than of salt. Consequently, it is likely that the salt secretion is more severely disturbed by a kidney injury than water elimination. Both are additionally dependent on the heart activity. Many reasons support this in the sense that the heart acts as a pump mechanism more for water elimination than for salt secretion. We will then expect during a disturbance of the heart activity, that foremost will be the primary hindrance of water elimination while we consider the primary salt retention as more essential in kidney injury. The symptoms of disturbed heart and kidney activity are almost always present during the fever of pneumonia victims. The answer to the question is therefore especially difficult.

In order to come at least somewhat nearer to the cause, I have investigated in several cases how the pneumonia victim in the convalescence stage reacts to large salt doses. In curves 2,3,4 and 5 the salt additions are indicated. In curve 2, there resulted a positive chloride balance from a single addition of 3 g sodium chloride. A broad conclusion can still not be drawn from this because normally salt introduced in large quantities is only secreted on the next day. This indicated a control experiment which I have carried out on myself. In this experiment, over a three day period,

a total of 33 g NaCl were taken and 32 g NaCl eliminated (the retention of 1 g lies inside the limits of error). The largest salt assimilation took place on the second day of the experiment. On this day, the previously somewhat reduced NaCl elimination also increased, however, without entirely attaining the amount of supply. The heaviest elimination, which restored the balance, took place on the third experimental day.

In case 3, the salt administered three days in succession was promptly eliminated.

In case 4, a single addition of 4 g salt was given on the fifth day after the crisis -- the salt balance was already negative at this time. It was partly retained and eliminated only on the next day. Thereupon about 4 g of salt were administered on the eighth, ninth and tenth days after the crisis, a total of 12 g. These 12 g were completely retained for three days and were partly eliminated only on the two following days. This case seems to me to support the contention that a mild hindrance of salt secretion was present. For, during this time, the water elimination by the kidneys was not hindered, but the salt concentration of the urine was severely lowered -- from 0.[illegible]% to 0.56%. Therefore, it can probably be assumed that salt retention was primary here (not limited by water retention). Since additional disturbances of the heart activity were not observed during this time, the cause of the retention should be sought in the kidneys. For this reason, this case was interpreted as a disturbance of the salt-eliminating function of the kidneys. If such a disturbance was still evident 8-10 days after the crisis, it can be presumed that it was still more severe during the fever period. Albumen in the urine was also evident at this time.

In case 5, since the patient was already in the salt elimination period, 3.0 g of added salt were administered on the fifth, sixth and seventh day after fever decline, a total of 13 g NaCl. It was partly retained, partly eliminated, in the two days following, while on the third day, NaCl retention occurred again. The same salt additions were administered again on the eleventh, twelfth and thirteenth days with the same result except that this time, salt equilibrium occurred on the third day after the additions.

This case also supports the hindrance of salt retention by the kidneys and makes salt retention as the primary probable. For water elimination through the kidneys was not affected, but the salt concentration was strongly reduced each time -- the first time from 1.30% to 0.35%, the second time from 1.[illegible]% to 0.67%. In this case, where albumen in the urine was no longer evident, the salt-eliminating function of the kidneys was still disturbed for a time.

The fact that this functional disturbance was not found in all cases is not counterevidence. For we could investigate for a time the possible ways in which the kidney impairment had passed. However, if there is still a functional disturbance of the kidneys present at all after the lapse of fever, this signifies that this disturbance is not limited as such by the temperature rise, and therefore is not in the strictest sense "febrile". The assumption that an impairment of the secreting elements of the kidneys

is caused by the toxins circulating and passing through the body and partly through the kidneys for elimination seems much more clear and very obvious to us.

It can easily be demonstrated that salt retention arising in the whole organism results in water retention and that the blood dilution and the body weight increase are due to this.

Footnotes

1. "Investigations on Fever" Deutsches Archiv fuer klinische Medizin (German Archives for Clinical Medicine) Volume V, 1869, pages 273-371.

2. Archiv fuer experimentell Pathologie und Pharmazie (Archives for Experimental Pathology and Pharmacy), Volumes LIV and LV.

3. Investigations on this are in progress.

4. Die Krankheiten der Respirationsapparates und Zirkulationsapparates (The Disease of the Respiratory and Circulatory Apparatus), Berlin, 1867.

5. Archiv fuer experimentell Pathologie und Pharmazie, Volume LV, p. 284

6. Cited by b. Hosslin, "The Sodium Chloride Exchange During Pneumonia." Archiv fuer klinische Medizin, 1903.

7. See Reiss, Diss., 1902.--Zeitschrift fuer experimentell Pathologie und Pharmazie (Journal of Experimental Pathology and Pharmacy), Volume 51, 1904. -- Zeitschrift fuer Elektrochemie (Journal of Electrochemistry), Volume 14, 1908.

8. See H. Luthje, for the question of the so-called febrile albumen urine besides several remarks on the significance of the cylinder. Therapie der Gegenwart (Therapy of the Present), November, 1903.